Πανελλήνιος Σύλλογος Διπλωματούχων Αγρονόμων & Τοπογράφων Μηχανικών
ΤΜΗΜΑ ΔΥΤΙΚΗΣ ΕΛΛΑΔΑΣ

Γεωργία Ακριβείας & Παρακολούθηση Φυσικού Περιβάλλοντος

Κωνσταντίνος Καράντζαλος

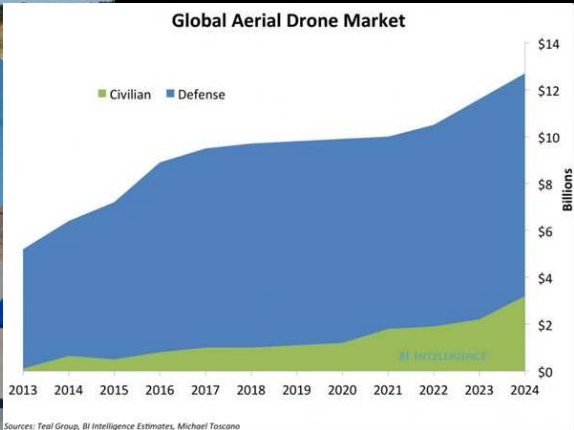
karank @ central.ntua.gr
http://users.ntua.gr/karank/

Εργαστήριο Τηλεπισκόπησης
Εθνικό Μετσόβιο Πολυτεχνείο

Market

numbers

- ✓ *global UAV market is expected to **grow** at a **10%** CAGR up to **2020***



Market

4x Heron ..550 hours of surveillance per month

numbers

- ✓ *10x … $400 million*

  Israel - India

Flirtey
Parrot
DRONE BASE
AVISION
ROBOTICS
THE FUTURE OF POSSIBLE
PRECISIONHAWK
UNMANNED VEHICLE UNIVERSITY
FLYSAFE
YUNEEC
ELECTRIC AVIATION
70 Drone Companies
To Watch in 2016
UAV Coach
BLADE
Airware
CHEERSON
LILY
GoPro
DroneView
TECHNOLOGIES
DroneDeploy
SILVERHAWK
AERIAL IMAGING
DRONEU
XPROHELI
POLAR PRO
3DR
amazon
Prime Air
DARTDRONES

Market

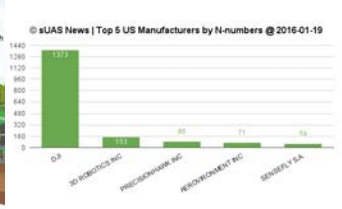
Agriculture drones market *$3.6 Billion* *by 2022*

[Market Watch, 2016]

Non-military applications *$6 Billion* *by 2020*

[Markets&Markets, 2015]

✓ *Global UAV Market* *from $10 Billion in 2015* *to $15 Billion by 2020*



JUMBO

Drones - Ελικόπτερα

Jumbo Πρόταση | Προϊόντα ανά σελίδα: 48

[Κωδ. 1115605]

Τηλεκατευθυνόμενο Ελικόπτερο Υπερύθρων

Drones - Ελικόπτερα

Τιμή: **9,99 €**

Προσθήκη στο Καλάθι

[Κωδ. 1145748]

Τηλεκατευθυνόμενο Μίνι DRONE 2.4 GHZ

Drones - Ελικόπτερα

Τιμή: **19,99 €**

Προσθήκη στο Καλάθι

[Κωδ. 1136255]

Τηλεκατευθυνόμενο DR GHZ SYMA

Drones - Ελικόπτερα

Τιμή: **29,99 €**

Προσθήκη στο Κ

[Κωδ. 1140819]

Τηλεκατευθυνόμενο DRONE 2.4 GHZ WIFI-CAM-VIDEO (συμβατό με SmartPhones)

Drones - Ελικόπτερα

Τιμή: **69,99 €**

Προσθήκη στο Καλάθι

[Κωδ. 1140808]

Τηλεκατευθυνόμενο DRONE 2.4 GHZ WIFI-CAM-VIDEO (συμβατό με SmartPhones)

Drones - Ελικόπτερα

Τιμή: **99,99 €**

Προσθήκη στο Καλάθι

skroutz

Drones (388 προϊόντα)

Αύξουσα τιμή | 1 2 ... 13

Eachine H8 Mini Headless Mode 2 1909899

Τετρακόπτερο

23,90 €

στα Συνεστόνες

OEM Mingji MJ 102 RC Quadcopter Invade 2.4ghz MJ102

Τετρακόπτερο

24,90 €

στο Afasia

OEM Quadcopter Mingji S-Eye 108 24141

Τετρακόπτερο

24,90 €

στο Afasia

Cheerson CX-10A Mini Silver

Τετρακόπτερο

24,90 €

στο Afasia

Cheerson CX-10A Mini White

Τετρακόπτερο

24,90 €

στο Afasia

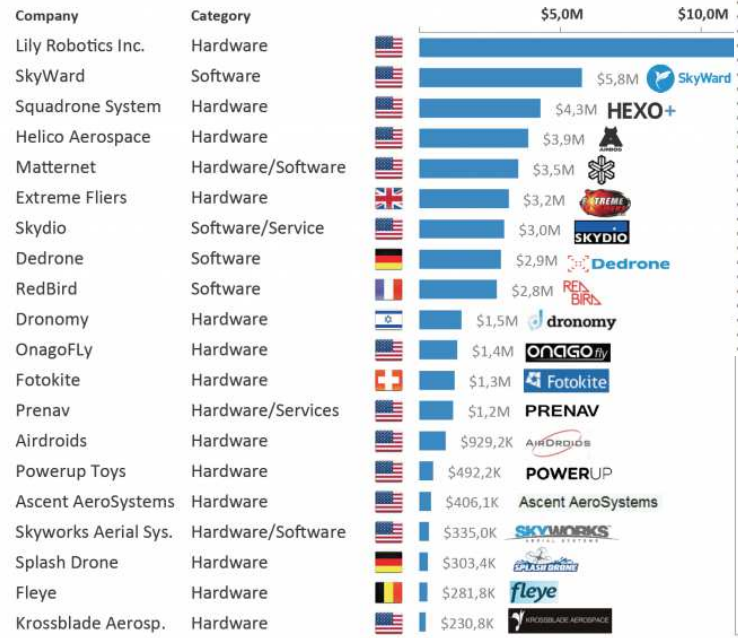
Cheerson CX-10A Mini Gold

Τετρακόπτερο

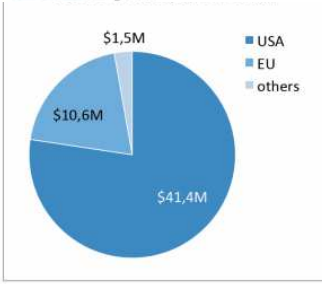
24,90 €

στο Afasia

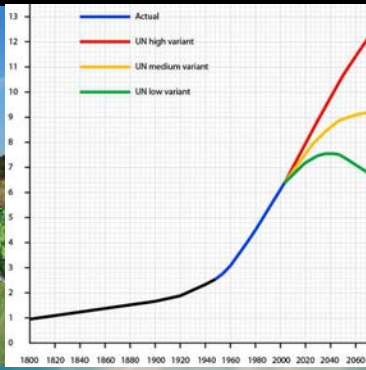
Market



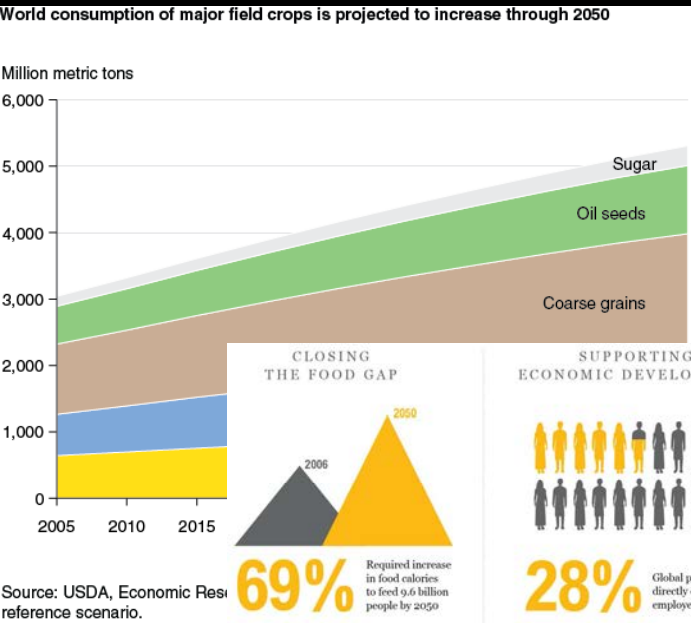
- SkyTech London, UK
- RPAS CivOps 2016 Brussels, Belgium
- TUSExpo The Hague, Netherlands
- Drone Days Brussels, Belgium
- Dronemasters Summit @CeBIT Hannover, Germany
- AUVSI's Unmanned Systems Europe 2016 Brussels, Belgium
- Drone Expo Dublin, Ireland
- EuropaDrone Lyon, France
- European UAV Traffic Management Day Geneva, Switzerland
- DroneConvention 2016 Genk, Belgium
- DroneFest Toulouse, France
- Unmanned Solutions Forum Bucharest, Romania
- Roma Drone Conference Rome, Italy
- Unmanned Cargo Aircraft Conference Enschede, Netherlands
- Drone Expo Greece Athens, Greece
- Nordic UAS Event Odense, Denmark
- UAV Remote Sensing Applications Course Barcelona, Spain
- Unmanned Global Systems Paris-Nord-Villepinte, France
- RPAS Conference 2016 Brussels, Belgium
- UK Drone Show At Farnborough International Airshow Farnborough, UK
- Drone Experience Nantes, France
- UASympEx Hamburg, Germany
- ExpoDrónica Zaragoza, Spain
- Dronemasters Logistics Hannover, Germany
- Dronitaly Milan, Italy
- RAeS Annual Conference London, UK
- Interaerial Solutions Hamburg, Germany
- DroneTech Torun, Poland
- UAV Show France Bordeaux, France
- Drone Berlin Berlin, Germany
- OverHead Prague, Czech Republic
- Commercial UAV Show London, UK
- Drones Data X Conference – Ireland Dublin/Westport, Ireland
- Catalonia Smart Drone Event Barcelona, Spain
- UK Drone Show Birmingham, UK

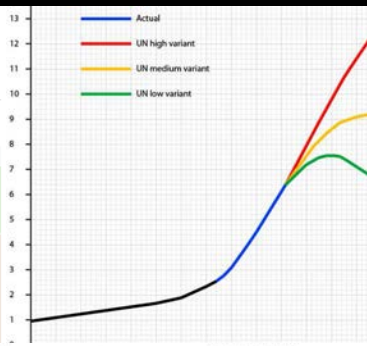


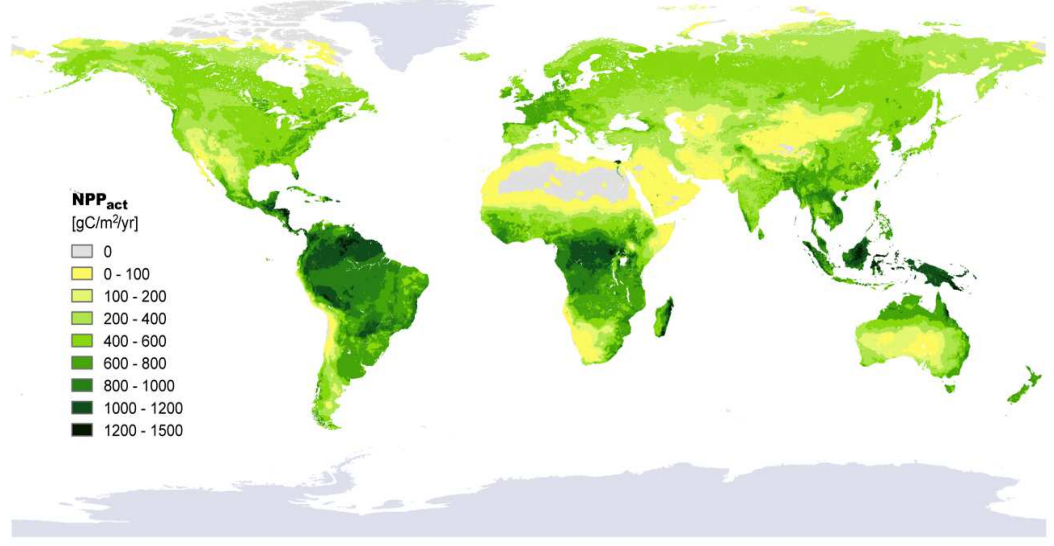
Precision Agriculture.. ..why?



Precision Agriculture.. ..why?






NPP act
[gC/m2/yr]
0
0 - 100
100 - 200
200 - 400
400 - 600
600 - 800
800 - 1000
1000 - 1200
1200 - 1500

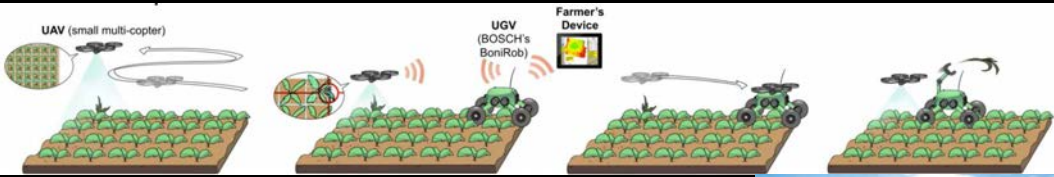
Precision Agriculture

Precision Agriculture

- ***Crop Management***
- ***Selective Harvesting***

Precision Agriculture

- *Crop Management*
- *Selective Harvesting*



- *Platforms (drone, fixed-wing)*
- *Sensors (RGB, Mutlispectral, etc)*
- *Application (Viticulture, Horticulture, etc)*

Precision Agriculture

Platforms

- ❖ *Drones*
- ❖ *Fixed-wing*

Precision Agriculture

Platforms

- *Drones*
- *Fixed-wing*

Precision Agriculture

Platforms

- *Drones*
- *Fixed-wing*

- *Drones*
- *Fixed-wing*

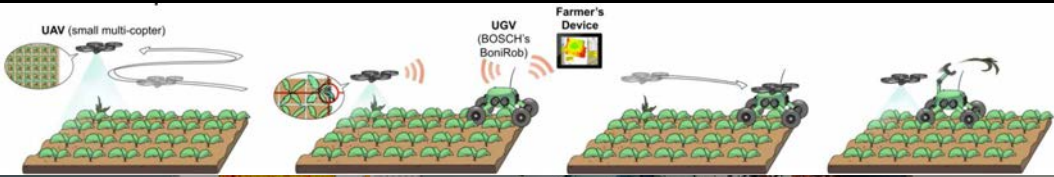
Precision Agriculture

Platforms

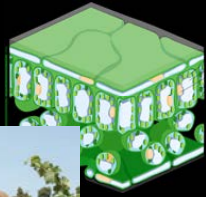
- *Drones*
- *Fixed-wing*

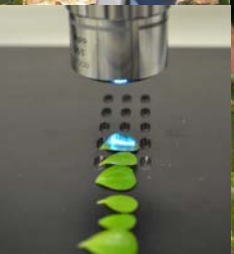
Precision Agriculture

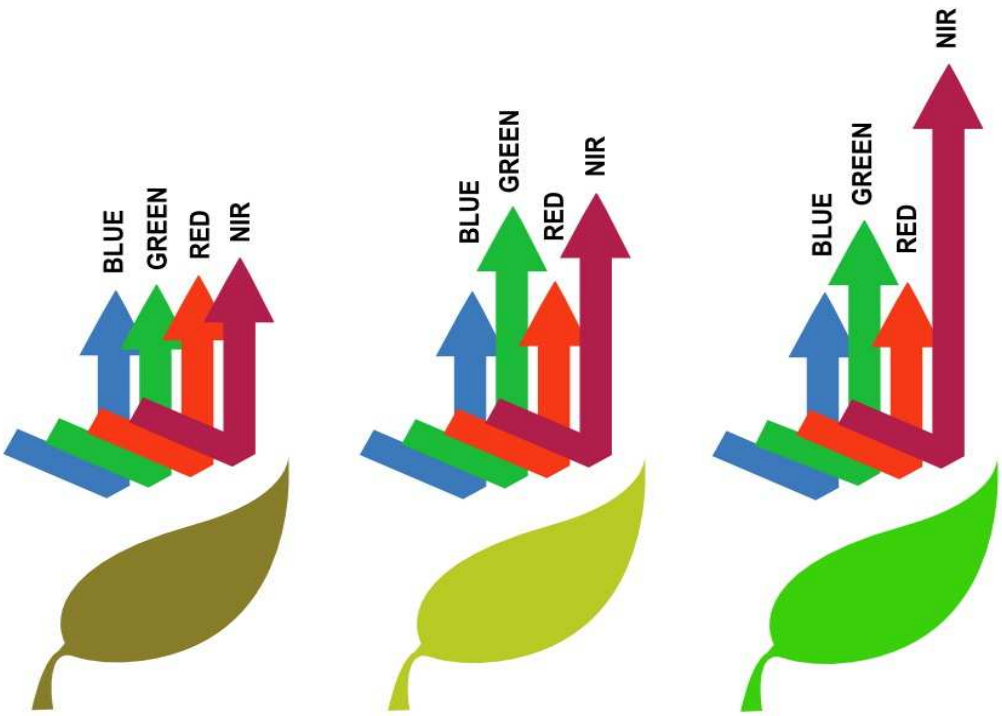
- ***Crop Management***
- ***Selective Harvesting***

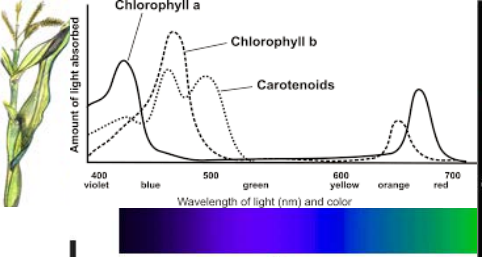


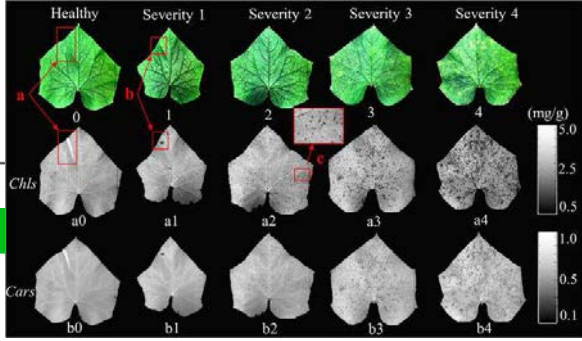
Reflectance

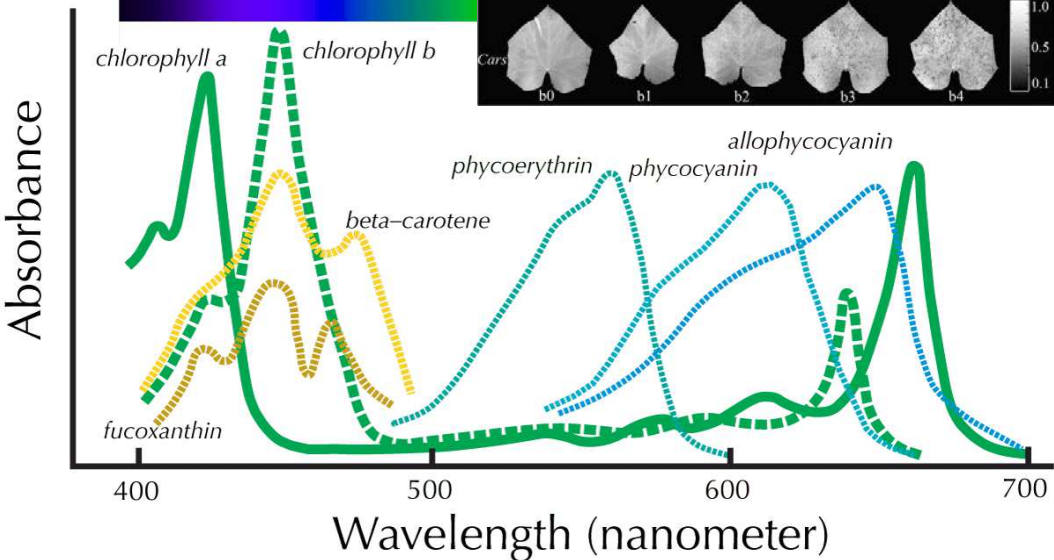




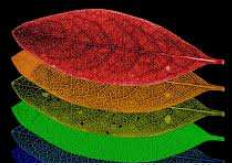

BLUE
GREEN
RED
NIR
BLUE
GREEN
RED
NIR
BLUE
GREEN
RED
NIR
Dead Leaf
Stressed Leaf
Healthy Leaf

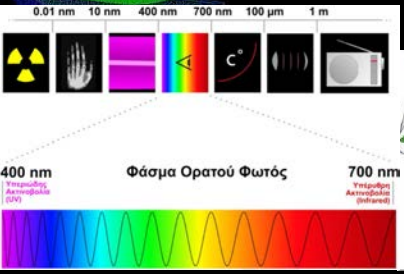

Chlorophyll a
Chlorophyll b
Carotenoids
Amount of light absorbed
400
violet
500
blue
600
green
700
yellow
orange
red
Wavelength of light (nm) and color

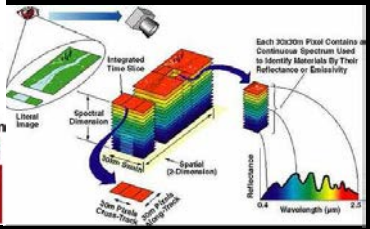

Healthy
Severity 1
Severity 2
Severity 3
Severity 4
a
b
c
0
1
2
3
4
(mg/g)
5.0
2.5
0.5
Chls
a0
a1
a2
a3
a4
1.0
0.5
0.1
Cars
b0
b1
b2
b3
b4


Absorbance
chlorophyll a
chlorophyll b
beta–carotene
fucoxanthin
phycoerythrin
phycocyanin
allophycocyanin
400
500
600
700
Wavelength (nanometer)

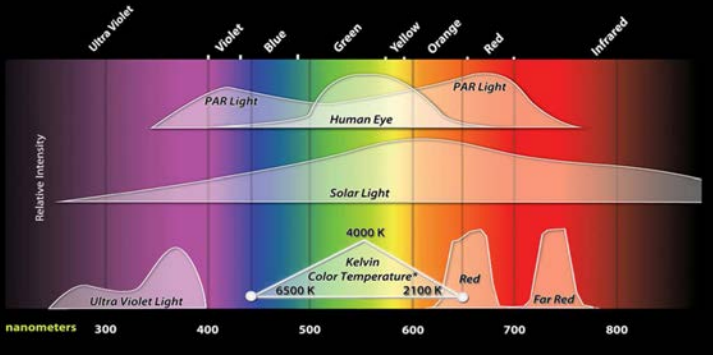
Sensors

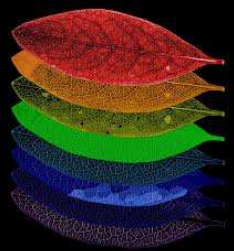






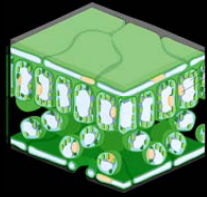
- *RGB*
- *Multispectral*
- *Hyperspectral*
- *SWIR*
- *…*





Precision Agriculture

Sensors

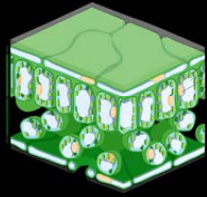


Wavelength (mm)		Effect on Plant Growth
UV (Invisible)	280	Significantly reduces quantum yield and rate of photosynthesis.
	315~400	Promotes pigmentation, thickens plant leaves, and may be used to prevent harmful insects.
Visible Spectrum	440~470	Chlorophyll absorption peaks at 439mm and 469mm. The blue spectrum is the most efficiently absorbed spectrum, promoting mainly vegetative growth.
	510	Quantum absorption in the green spectrum. Little absorption is the yellow spectrum.
	610	No chlorophyll benefit. Efficiently absorbed by algae phycoerythrin and phycocyanin receptors.
	640~660	Chlorophyll absorption peaks at 642mm and 667mm. 660mm is the most vital wavelength for flowering. Speeds up seed germination and flower/bed onset.
	740	Emerson Enhancement Effect - quantum yield of red light and far red light, when shone simultaneously on a plant, increases the rate of photosynthesis.
Infrared	1000~1400	No plant activity detected at this wavelength. Heat generated.

- ***RGB***
- ***Multispectral***
- ***Hyperspectral***
- ***SWIR***
- ***…***

Precision Agriculture

Sensors



PLANET LABS

DigitalGlobe

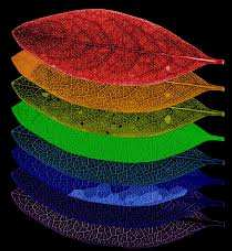
RapidEye
Delivering the World

Terra Bella

URTHECAST

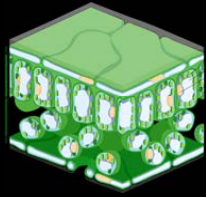
- ***RGB***
- ***Multispectral***
- ***Hyperspectral***
- ***SWIR***
- ***…***

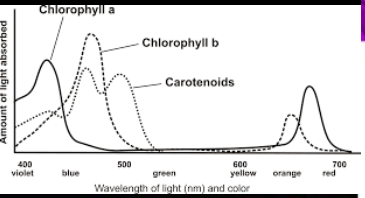
DATA ARC · NASA · esa · JAXA · CSA ASC

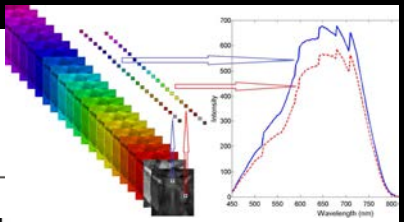


Precision Agriculture

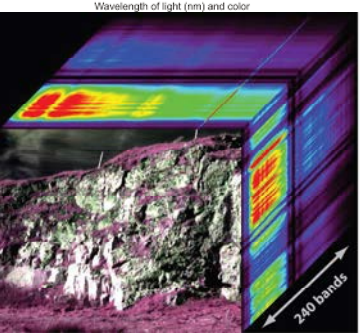
Sensors

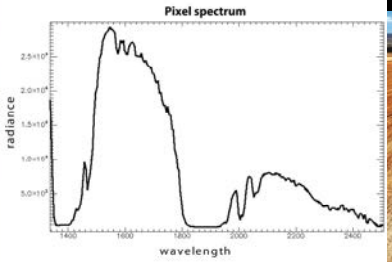


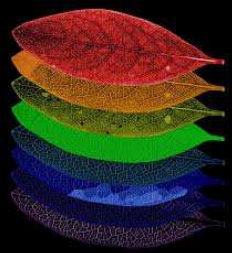




- ***RGB***
- ***Multispectral***
- ***Hyperspectral***
- ***Thermal***
- ***…***

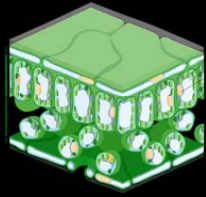






Precision Agriculture

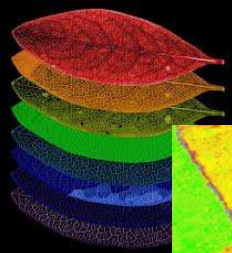
Sensors

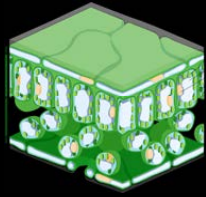


- *RGB*
- *Multispectral*
- *Hyperspectral*
- *Thermal*
- *…*

Headwall PHOTONICS imec ximea 3D-ONE FLIR Xenics Infrared Solutions

NDVI color-maps..

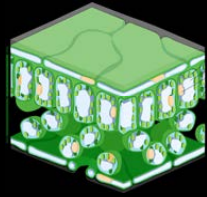




- *RGB*
- *Multispectral*
- *Hyperspectral*
- *Thermal*
- *…*

NDVI color-maps..

Sensors



Απορροφούμενη Φωτοσυνθετικά Ενεργή Ακτινοβολία
FAPAR

Δείκτης Φυλλικής Επιφάνειας
LAI

Ecological Applications, 5(1), 1995, pp. 28–41
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RELATIONSHIPS BETWEEN NDVI, CANOPY STRUCTURE, AND PHOTOSYNTHESIS IN THREE CALIFORNIAN VEGETATION TYPES[1]

JOHN A. GAMON,[2] CHRISTOPHER B. FIELD, MICHAEL L. GOULDEN,[3] KEVIN L. GRIFFIN,[4] ANNE E. HARTLEY,[4] GEESKE JOEL, JOSEP PEÑUELAS,[5] AND RICCARDO VALENTINI[6]
Carnegie Institution of Washington, Department of Plant Biology, Stanford, California 94305 USA

Abstract. In a range of plant species from three Californian vegetation types, we examined the widely used "normalized difference vegetation index" (NDVI) and "simple ratio" (SR) as indicators of canopy structure, light absorption, and photosynthetic activity. These indices, which are derived from canopy reflectance in the red and near-infrared wavebands, highlighted phenological differences between evergreen and deciduous cano-

NDVI color-maps..

Sensors

Απορροφούμενη Φωτοσυνθετικά Ενεργή Ακτινοβολία
FAPAR

Δείκτης Φυλλικής Επιφάνειας
LAI

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RELATIO
STRUCTURI
CALI

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 111, D08S11, doi:10.1029/2005JD006017, 2006

Relationship between gross primary production and chlorophyll content in crops: Implications for the synoptic monitoring of vegetation productivity

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[1] Accurate estimation of spatially distributed CO_2 fluxes is of great importance for regional and global studies of carbon balance. We applied a recently developed technique for remote estimation of crop chlorophyll content to assess gross primary production

GEOPHYSICAL RESEARCH LETTERS, VOL. 32, L08403, doi:10.1029/2005GL022688, 2005

Remote estimation of canopy chlorophyll content in crops

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[1] Accurate estimation of spatially distributed chlorophyll content (Chl) in crops is of great importance for regional and global studies of carbon balance and responses to [illegible] this paper a recently [illegible]pplied for remotely canopies. We tuned reflectance at intermediate to high Chl [e.g., *Kanemasu*, 1974; *Buschmann and Nagel*, 1993] limits the applicability of such techniques. Other studies have shown that reflectance in the green and red edge regions is sensitive to a wide range of Chl [*Thomas and Gausman*, 1977; *Buschmann and Nagel*, 1993; *Gitelson et al.*, 1996a, 1996b]. Vegetation

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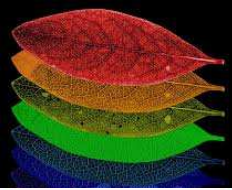
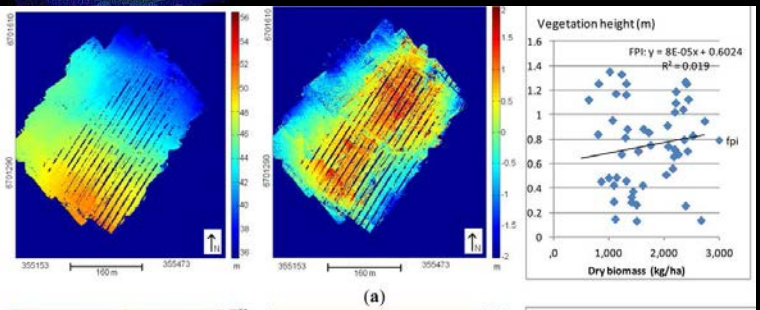
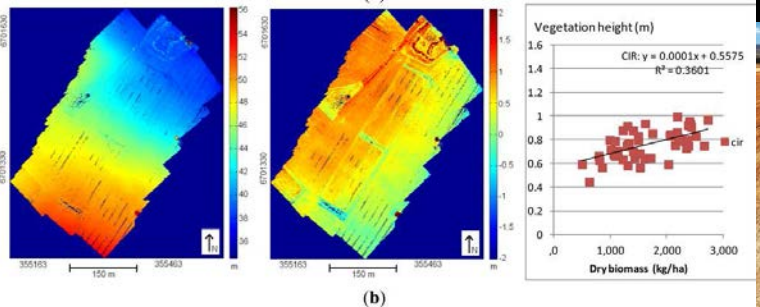
m three Californian vegetation types. we
ice vegetation index" (NDVI) and "simple
ght absorption, and photosynthetic activity.
y reflectance in the red and near-infrared
es between evergreen and deciduous cano-

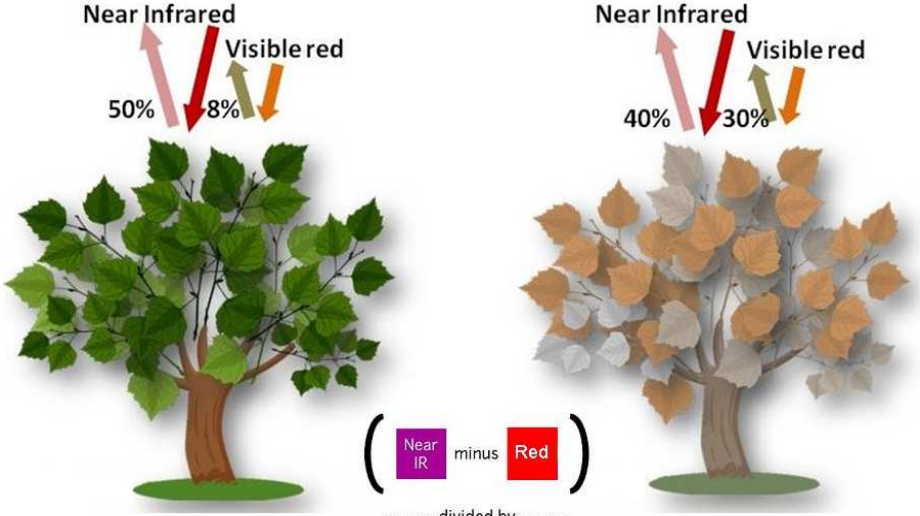
Reflectance

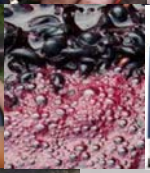


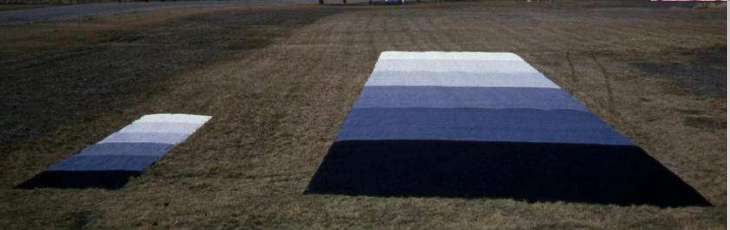


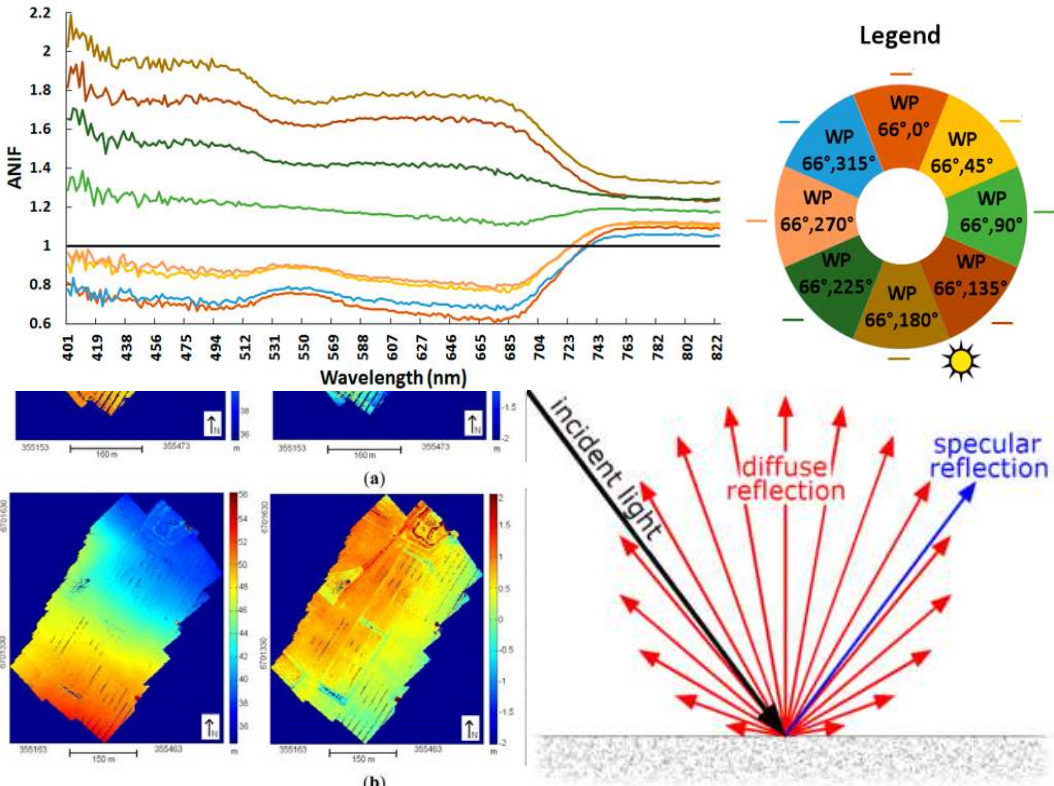


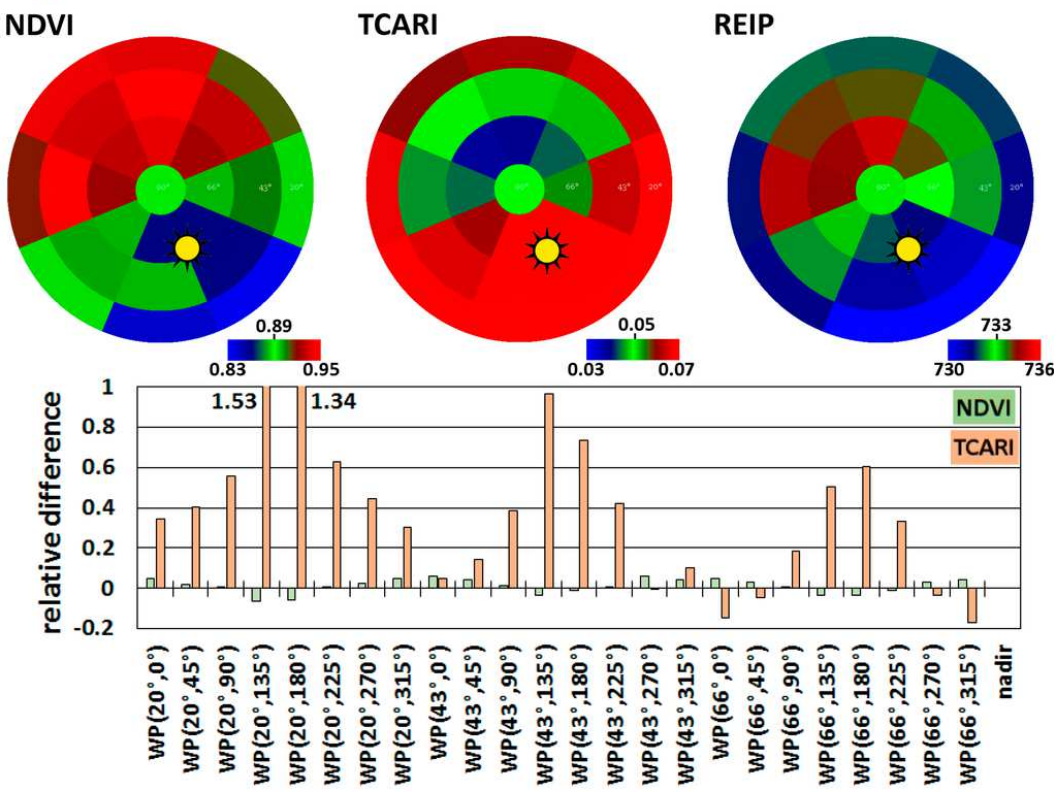
- ***RGB***
- ***Multispectral***
- ***Hyperspectral***
- ***Thermal***
- ***…***


Near Infrared
Visible red
50%
8%
Near Infrared
Visible red
40%
30%
(Near IR minus Red)
----------divided by----------
(Near IR plus Red)
$\frac{0.50-0.08}{0.50+0.08}=0.72$
$\frac{0.4-0.3}{0.4+0.3}=0.14$
Healthy
Unhealthy

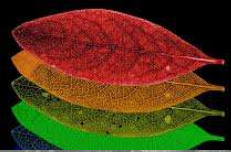


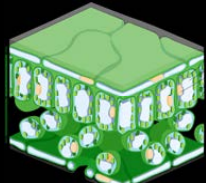



ANIF
Wavelength (nm)
Legend
WP 66°,0°
WP 66°,45°
WP 66°,90°
WP 66°,135°
WP 66°,180°
WP 66°,225°
WP 66°,270°
WP 66°,315°
(a)
(b)
incident light
diffuse reflection
specular reflection


NDVI
TCARI
REIP
0.89
0.83
0.95
0.05
0.03
0.07
733
730
736
relative difference
1
0.8
0.6
0.4
0.2
0
-0.2
1.53
1.34
NDVI
TCARI
WP(20°,0°)
WP(20°,45°)
WP(20°,90°)
WP(20°,135°)
WP(20°,180°)
WP(20°,225°)
WP(20°,270°)
WP(20°,315°)
WP(43°,0°)
WP(43°,45°)
WP(43°,90°)
WP(43°,135°)
WP(43°,180°)
WP(43°,225°)
WP(43°,270°)
WP(43°,315°)
WP(66°,0°)
WP(66°,45°)
WP(66°,90°)
WP(66°,135°)
WP(66°,180°)
WP(66°,225°)
WP(66°,270°)
WP(66°,315°)
nadir

Reflectance



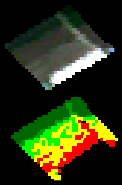


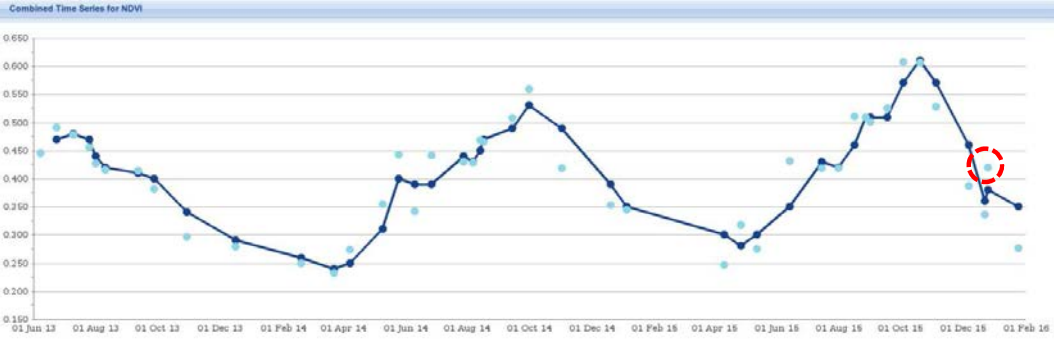
Landsat 8
29 July 2014

RapidEye
17 Aug 2014

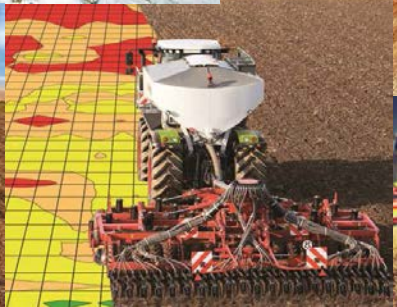
Landsat 8
4 Oct 2015

Sentinel-2
26 Dec 2015





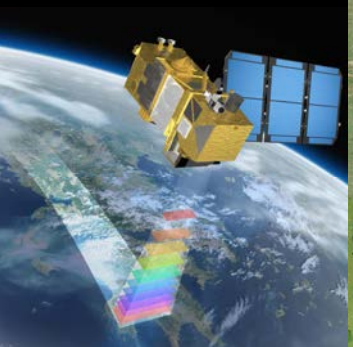
Precision Agriculture



Leaf Area Index
(m²)
<1
1.0 - 1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
>4.5

Διαχρονική Παρακολούθηση

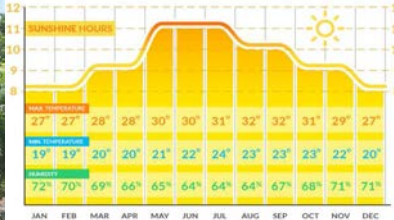
- ✓ Δορυφορικά Τηλεπισκοπικά Πολυφασματικά Δεδομένα
- ✓ Μη Επανδρωμένα Εναέρια Οχήματα
- ✓ Υπερφασματικά Δεδομένα Πεδίου
- ✓ Δειγματοληψίες Σταφυλιού
- ✓ Εργαστηριακές Αναλύσεις

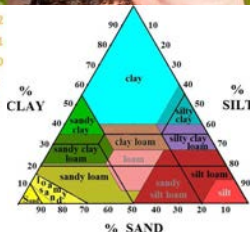


Λήψη Βέλτιστων Αποφάσεων

Έγκαιρη & Έγκυρη Διάγνωση
Λήψη Ορθολογικών Αποφάσεων

- ✓ **Συνδυασμός μακροχρόνιας Γνώσης και Εμπειρίας με Δεδομένα:**
- ✓ **Παρακολούθησης**
- ✓ **Μετεωρολογικά, Κλιματικά, Εδαφολογικά**
- ✓ **Ανάλυση Ανά Ποικιλία, Ανά Αμπελοτεμάχιο**





$ $ $ $

Environmental Monitoring

low-cost

low-weight

sensors

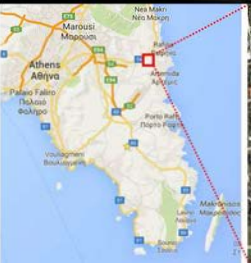
Environmental M

low-cost

low-weight

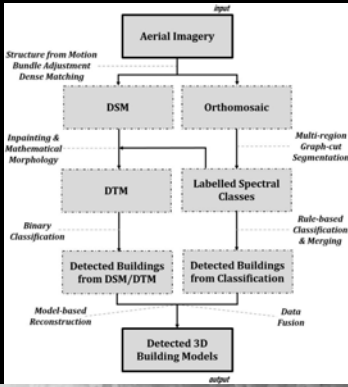
sensors

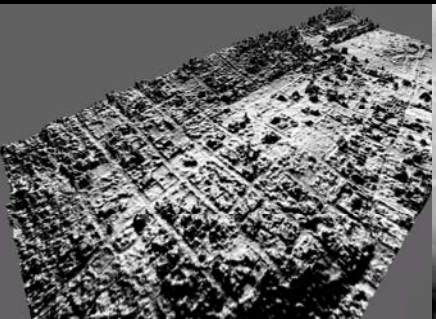
Environmental Monitoring



Environmental Monitoring

Environmental Monitoring





Environmental Monitoring

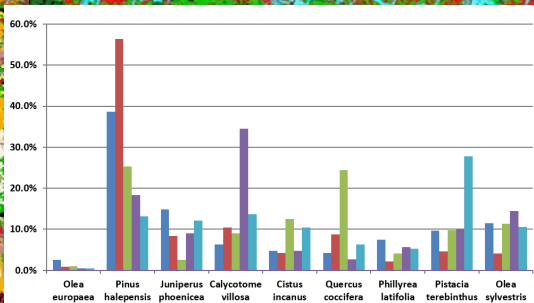
Environmental Monitoring

Environmental Monitoring

Environmental Monitoring

Χαρτογράφηση Φυσικής Αναγέννησης σε καμένες εκτάσεις

Εκτίμηση Καύσιμης Ύλης

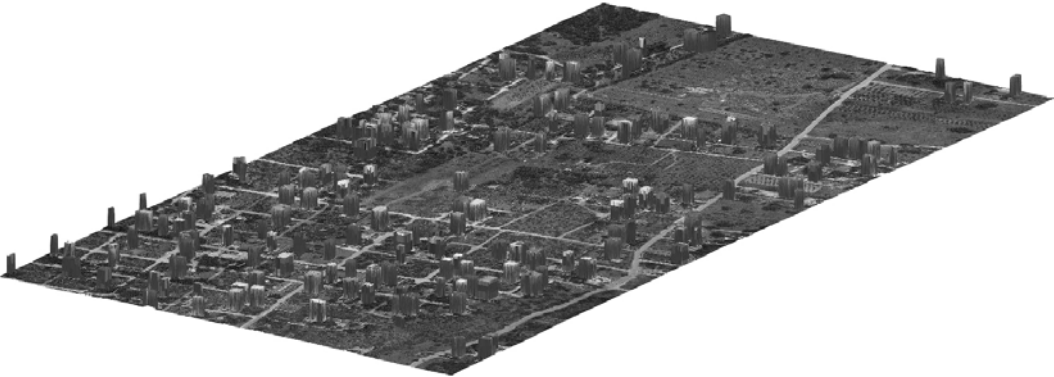


Environmental Monitoring

Χαρτογράφηση και διαχωρισμός ειδών βλάστησης

Ερημοποίηση, κοκ

Environmental Monitoring

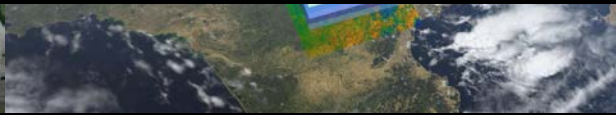


Environmental Monitoring

Precision Agriculture

- ***Crop Management***
- ***Selective Harvesting***

- ✓ Karakizi et al., **2016**., *Vineyard Detection and Vine Variety Discrimination from very High Resolution Satellite Data*, Remote Sens. 8, 235, doi:10.3390/rs8030235.
- ✓ Karmas et al. **2016**. *Big Geospatial Data for Environmental and Agricultural Applications*, Yu and Guo (eds.), Springer International Publishing.
- ✓ Kandylakis & Karantzalos, **2016**. *Precision viticulture from multitemporal, multispectral very high resolution satellite data*, ISPRS Archives.
- ✓ Kalisperakis et al., **2015**. Leaf area index estimation in vineyards from UAV hyperspectral data, 2D image mosaics and 3D canopy surface models, ISPRS UAV-g
- ✓ Karakizi et al., **2015**. Spectral Discrimination and Reflectance Properties of Various Vine Varieties from Satellite, UAV and Proximate Sensors, ISPRS Archives
- ✓ ….
- ✓ Kandylakis et al., **2013**. Evaluating Spectral Indices from WorldView-2 Satellite Data for Selective Harvesting in Vineyards, ECPA *[4th prize]*
- ✓ Karakizi et al., **2013**. Vineyard Detection and Vine Variety Discrimination from Satellite Data, ECPA *[1st prize, best poster communication award]*



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